Space Weather Technical Forecast

Issued on Sunday 29 December 2024 at 13:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Radio Blackouts expected throughout. Chance of R3 blackouts.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity at GOES16 has been High, with a X1.1 flare observed from AR3936 at 29/0718 UTC. Much of the remainder of the activity appears to have emanated from AR3932 and AR3929 in the western quadrant and from AR3939 in the southeast. There has also been evidence of some flaring from beyond the eastern limb..

There are currently twelve sunspot regions on the disc, one of which is unnumbered. There are four regions of significance due to their complexity. AR3936 (Ekc/Beta-Delta), in the northwest disc remains the largest and most complex region. AR3932 (Dai/Beta-Delta) in the southwest still appears to show a possible weak delta spot in the trailing section, the lead portion has almost entirely faded to plage with the group only retaining bipolar status due to the presence of this small delta. AR3928 (Cso/Beta-Delta), to the south of AR3933, has seen significant fading of its trailing portion and is similarly trending towards a complex unipolar group, although there still appears to be a faint delta spot to the rear of the lead portion. AR3938 (Dsc/Beta-Gamma) in the northeast shows a fairly compact north-south configuration. AR3939 (Csi/Beta) and AR3941 (Csi/Beta-Gamma), both in the southeast, have developed a number of intermediate spots late on 28 Dec. The remaining regions are relatively small, simple and mostly unchanged.

Numerous CMEs have been observed leaving the disc on SOHO LASCO imagery over the past 24 hours. However, these mostly considered to have been far-sided in origin. A filament eruption and dimming event was observed on GONG H-alpha imagery in the vicinity of AR3939 around 28/1900 UTC, with a further potential CME observed from the vicinity of AR3939 at 29/0436 UTC. This latter event has been modelled and may have an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR remained at background levels but increased from an average of 300km/s to an average of 350km/s at 28/1300 UTC. Density was largely below average, although there was a sustained period of average to slightly above average levels 28/1740-2130 UTC with a peak of 18ppcc. The Interplanetary Magnetic Field (IMF) was weak through much of the period, but reached moderate levels intermittently from 29/0600 UTC. The north-south component remained weak but erratic, fluctuating between +4/-3nT for much of the period. Stronger fluctuations between +8 nT and -6nT were then observed from 29/0600 UTC onwards. Phi angle was mostly negative (towards the

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Sun), but rotated into a positive direction from around 29/1100 UTC. The net result of the above solar wind measures was Quiet geomagnetic activity throughout (Kp 0-1).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained at background throughout, well below the S1/Minor Radiation Storm threshold.

High energy electron flux (greater than 2MeV) at GOES16 was at Moderate levels, peaking at 28/1620 UTC at 590pfu. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold on a slightly declining trend. The 29/0001UTC observation was 1.78e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally Moderate solar activity is expected through the next four days, with an elevated risk of High activity, especially from AR3936. There is an increasing risk of activity from regions due to rotate onto the visible disc from the far side of the Sun.

Solar Wind / Geomagnetic Activity: No coronal hole fast winds or CMEs currently feature in the forecast. There is low confidence of CME glances through 30 Dec to 01 Jan, with a partial halo CME possibly arriving at Earth on 31 Dec, although this is still being modelled.

Geomagnetic activity is expected to be mainly Quiet, but with a Slight Chance of Unsettled to Active (Kp 3-4) intervals should any glancing CME effects occur between 30 Dec to 01 Jan. There is also a risk of G1/Minor Storm intervals should the partial halo from 29 Dec be Earth directed.

Energetic Particles / Solar Radiation: There is a Slight Chance of S1/Minor Radiation Storm or greater enhancements during the period, this risk slightly increases later in the period as the larger groups rotate into a more favourable position. Electron flux levels remain Moderate but are expected to gradually ease into the period in the absence of any enhancement.

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Geomagnetic Storms

No CMEs or coronal hole high speed streams are forecast through the next four days.

A filament lift off from the southeast quadrant, close to AR3939 around 29/0436 UTC appears to have produced a fast partial halo CME, which has been analysed and submitted for modelling. This is potentially the fastest of a series of CMEs, and has a possible Earth directed component, so was prioritised for analysis. The most likely window for the arrival of this feature, should it be Earth directed would be on 31 Dec, but the results of the analysis are required before a more accurate arrival time can be determined. There is a further potential partial halo yet to be analysed, with a likelihood that this earlier CME was farsided. A number of CMEs are currently modelled in Enlil on the Sun-Earth line with a potentially for a series of low confidence passages from 30 Dec to 01 Jan.

Solar winds are otherwise are averaging around 350km/s and are expected to remain at background levels in the absence of any high speed stream of coronal hole activity.

Geomagnetic activity is forecast to be mainly Quiet, with a risk of Unsettled to Active intervals from 30 Dec to 01 Jan due to week CME passes. There is also a slight chance of G1/Minor Storm intervals due to the potential arrival of the CME from earlier on 29 Dec, although this will be reviewed when the CME has been fully modelled.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	15	15
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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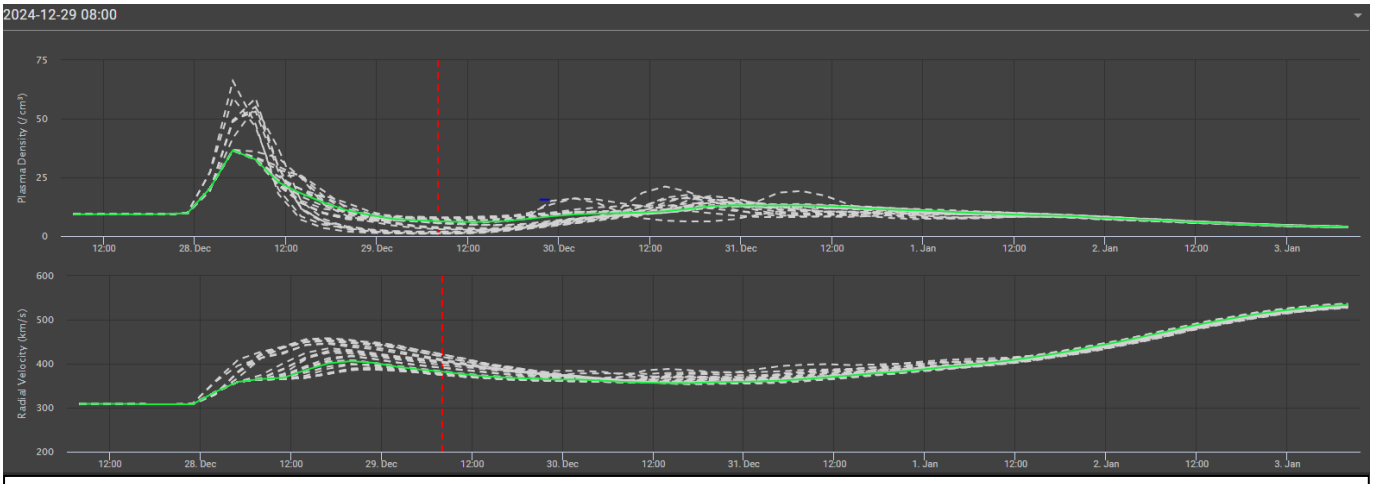
Figure 1: Enlil ensemble forecast showing the potential for weak CME arrivals on 30 Dec to 01 Jan.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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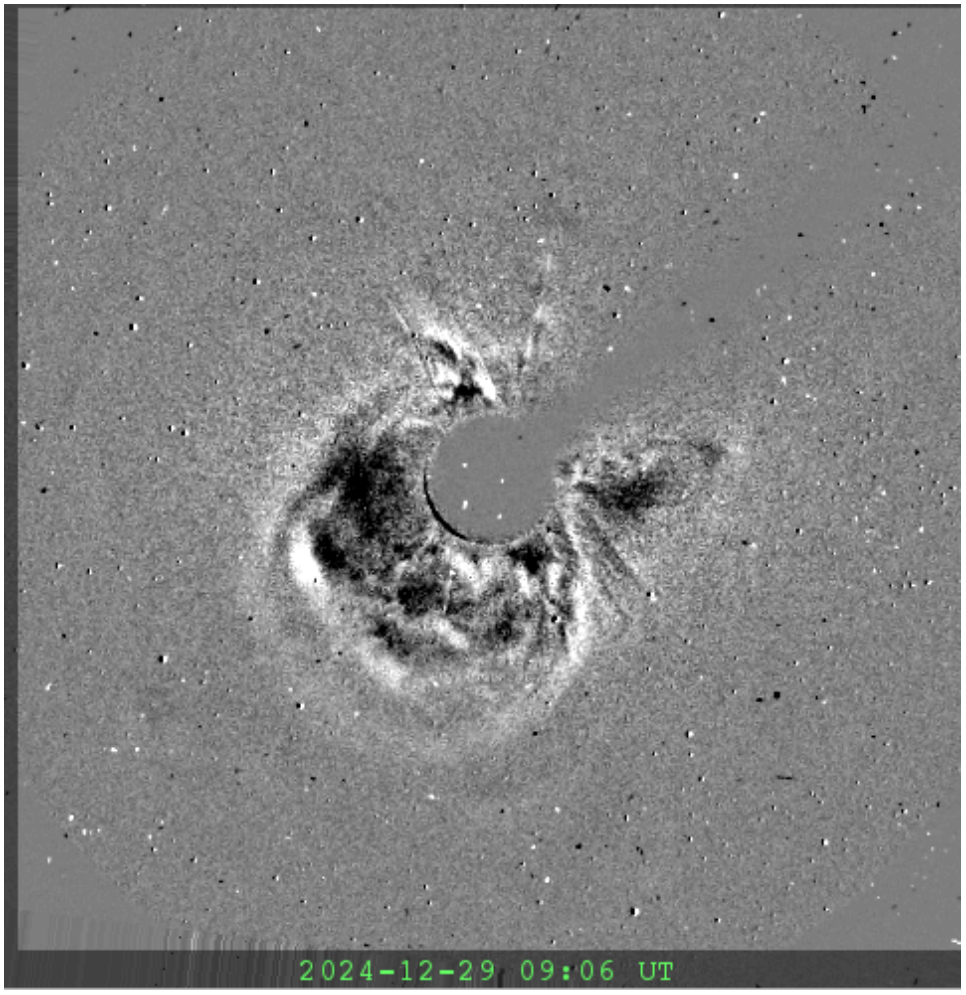
Figure 2: SOHO LASCO C3 difference imagery, showing the partial halo CME which is currently being modelled for the risk of an Earth directed component.



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Radio Blackouts - X-Ray Flares

There are 12 sunspot regions on the visible disc, with two regions containing delta spots. There was an X1.1 flare early on 29 Dec from AR3936. a large and complex feature in the northwest quadrant.

Recurrence suggests the potential for further sunspot regions to round the eastern limb during the period, with this supported by recent far-side CME activity. Although far-side sounding output is not showing any significant regions (likely due to their proximity to the limb where soundings have a minimum ability to detect such regions) limb flux looping and coronagraph imagery suggests the presence of regions approaching the limb. None of the four sunspot regions of note are expected to rotate off of the disc during the forecast period, although AR3933 and AR3928 will lie close to the western limb.

Flare risk is expected to be Moderate through the period, with an elevated risk of X-class flares, especially from AR3936 and from regions due to rotate onto the visible disc across the eastern limb.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	90	90	90	90
Very Active	R3-R5 (X Class)	Yes	30	30	30	30

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Figure 3: The region responsible for the X1.1 flare (AR3936), is clearly visible in the northwest quadrant.

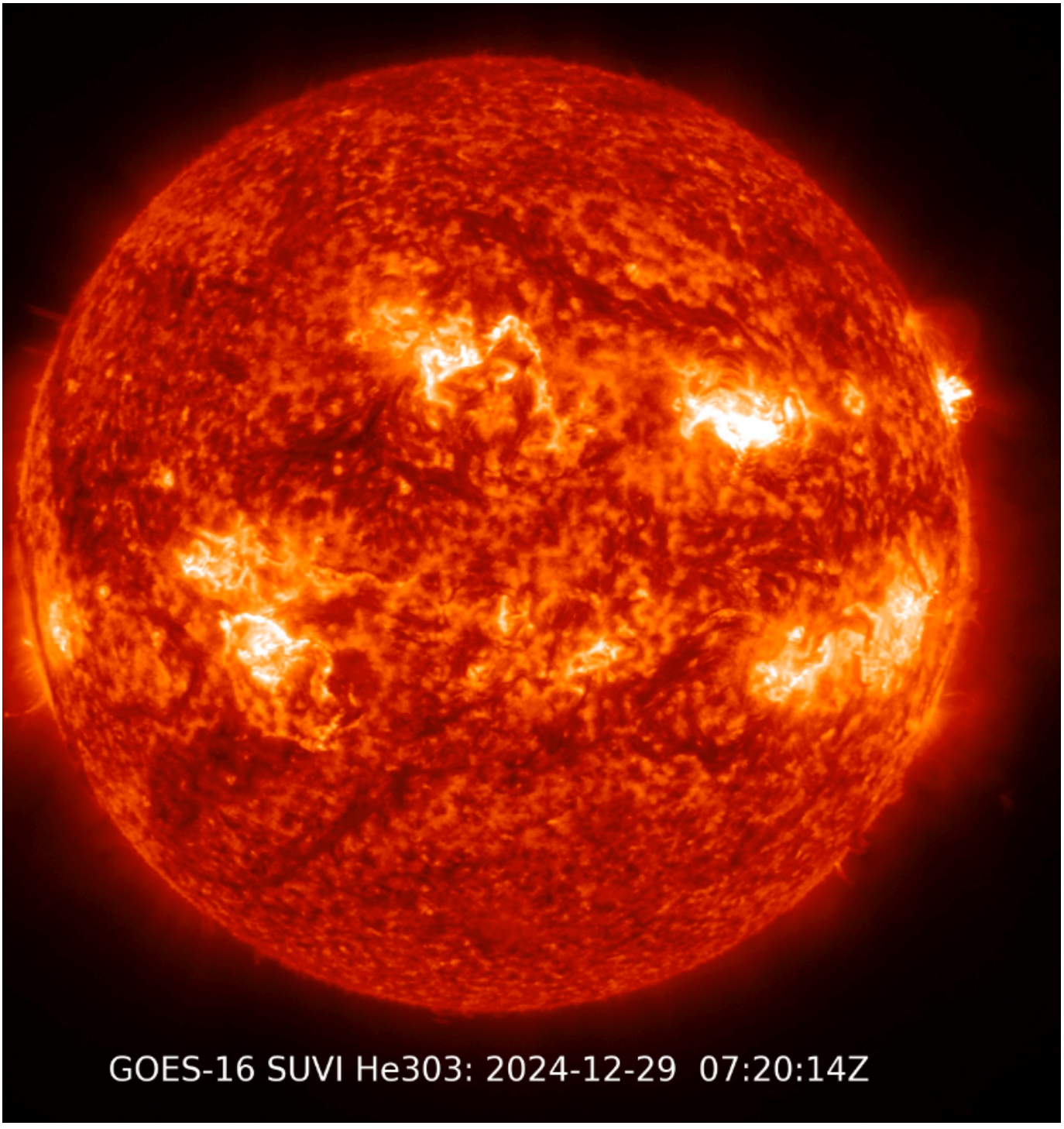

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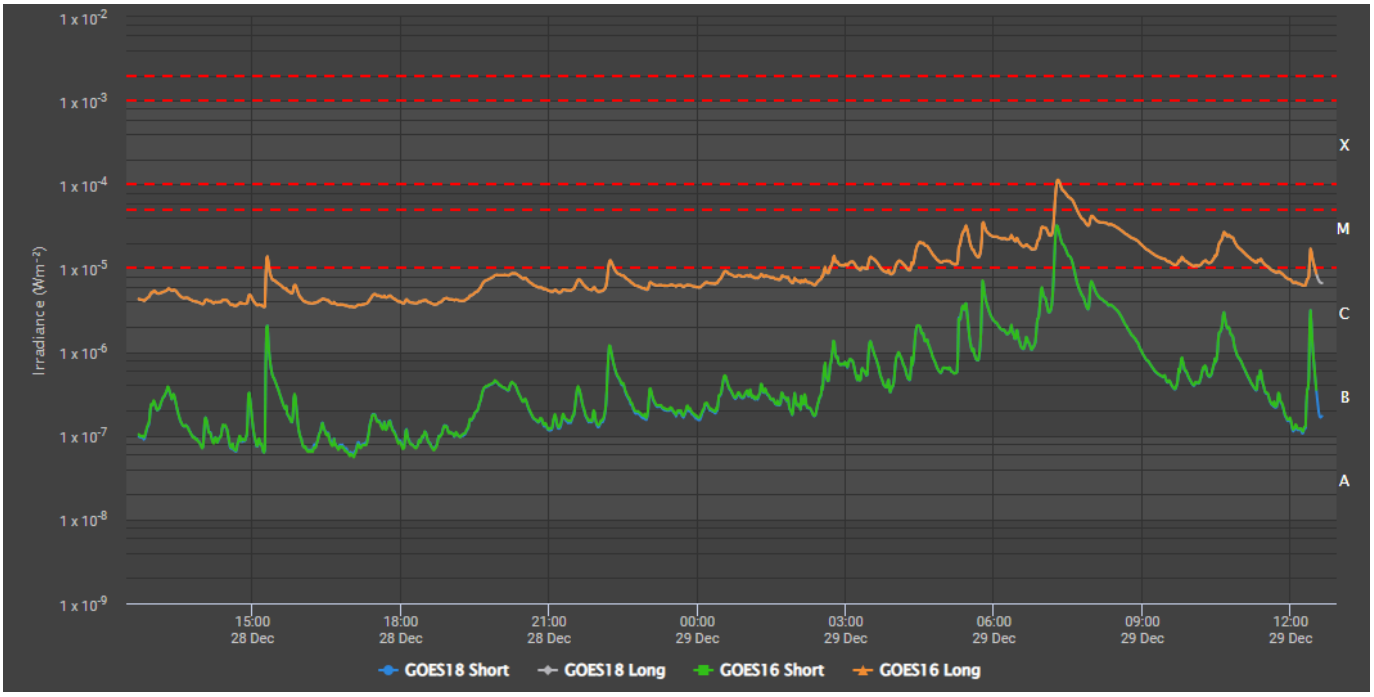
Figure 4: GOES 16 X-ray flare activity through the last 24 hours.



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Solar Radiation Storms (High Energy Protons)

High energy proton counts remain at background values, with neither the X1.1 flare from AR3936 or the filament eruption from the southeast quadrant resulting in a noticeable increase in proton counts. There remains a Slight Chance of S1/Minor Solar Radiation storms (or greater) should any significant flares occur from the larger regions on the disc as they rotate into more favourable locations for connection with Earth.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux has remained at Moderate levels in the last 24 hours. A steady state diurnal oscillation is expected through the period with a slightly declining trend towards background. With no further drivers to increase electron populations, fluence will now most likely remain below Active throughout. MOSWOC REFM is now showing a steady forecast through the next three days, which is considered good guidance.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	5	5	5	5
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

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